T BY 2000 SAVING SOIL

CLEAR LAKE ENHANCEMENT FEASIBILITY STUDY

L·A·P·O·R·T·E
PARK AND RECREATION

Prepared for
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Department of Parks and Recreation
LaPorte, Indiana

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CLEAR LAKE ENHANCEMENT PROJECT
Feasibility Study

TABLE OF CONTENTS

	Page
Executive Summary	i
List of Figures and List of Tables	ii
Introduction	
Background	1
Objectives	1
Scope of the Study	1
Acknowledgements	2
Physical Description of the Study Area	
Location	3
Lake Characteristics	3
Hydrogeology	6
Watershed Characteristics	7
Aquatic Resources	
Methods	9
Fisheries	9
Macrophytes and Phytoplankton	10
Water Quality	12
Other Resources	14
Problem Identification	
Lake Eutrophication Index	15
Results of Watershed Resident Questionnaire	17
Nonpoint Source Phosphorus Modeling	17
Conclusion	22
Lake Enhancement Alternatives	
Approach	23
Level One - Identification	23
Level Two - Screening	30
Level Three - Detailed Study	31
Recommendations for Implementation	34
References	35-36
Appendices	
A - Analytical Reports	
B - Results of Questionnaire	
C - Clear Lake Phosphorus Model	
D - Glossary of Technical Terms	

EXECUTIVE SUMMARY

The Clear Lake watershed encompasses an area of 278 acres. Clear Lake itself is 106 of these acres or 38% of the catchment area. There are four inlets to Clear Lake, draining the surrounding industrial, commercial, residential, and recreation lands. Industrial land is 29% (80 acres) of the catchment area; commercial land (downtown) is 17% (48 acres) of the catchment. Because the lake has no outlets other than seepage or evaporation, it retains all sediment and most other conservative (non-degradable) substances that enter the lake. This is an important aspect of Clear Lake; with the exception of negligible removal mechanisms, such as fish harvests and groundwater seeps, all phosphorus that enters the lake stays there and may be available year after year for production of macrophytes and plankton.

Water quality is rather fertile; sediment nutrient levels are moderate for a Hoosier lake. A Lake Eutrophication Index (LEI) based upon the Indiana Department of Environmental Management's system (IDEM, 1986) was updated for Clear Lake as part of this study. The IDEM computed a LEI in the mid-1970's to be 30 eutrophy points, designating it as a Class II lake (of four classes of lakes). The updated LEI is 22, a small improvement. Lakes with less than 25 eutrophy points are considered by IDEM to be Class I lakes, that is, the least eutrophic lakes in Indiana. In spite of the upgrading of Clear Lake to Class I, it is still clearly eutrophic, and is slowly evolving from a lake into a palustrine wetland. Visible symptoms of this aging are the abundance of wetland vegetation, shallowness, and phosphorus concentrations. Macrophytic vegetation and lake depth are not variables in the IDEM LEI, and likely explain the discrepancy between the LEI and an obviously eutrophic lake.

Phosphorus loadings to Clear Lake were estimated from land use information. Commercial and industrial lands are the two leading sources of phosphorus to the lake, at about 35% and 48% of the total phosphorus loading, respectively.

Alternative measures to enhance Clear Lake for the recreating public were identified and evaluated. Harvesting, as the only weed control method that removes nutrients and organic matter from the lake, is recommended for implementation. Watershed control of pollutant loadings is also recommended, through the development of sediment traps at the mouths of stormwater drains and implementation of Best Management Practices. It is recommended that the design phase include redesign of one existing (but deteriorated) sediment trap, and a determination of potential benefits of additional sediment traps at the other three storm inlets.

LIST OF FIGURES

Figure Number	Title
1	Location Map
2	Clear Lake Map
3	Groundwater Elevations in the Vicinity of Clear Lake
4	Vollenweider's Phosphorus Loading Plot
5	Sources of Phosphorus Entering Clear Lake

LIST OF TABLES

Table Number	Title
1	Land Use in the Clear Lake Watershed
2	Macrophytes in Clear Lake
3	Plankton in Clear Lake on September 1, 1989
4	Water Quality in Clear Lake
5	Water Quality Standards Applicable to Clear Lake
6	Sediment Quality Data
7	Lake Eutrophication Index
8	Nonpoint Source Phosphorus Loadings to Clear Lake
9	Alternatives for Controlling Aquatic Macrophytes in Clear Lake
10	Alternatives for Reducing Sediment and Phosphorus Loadings to Clear Lake
11	Nonpoint Pollutant Sources and Control Measures for Urban Watersheds
12	Macrophyte Harvesting Program

INTRODUCTION

Background

In the summer of 1989, the City of LaPorte Department of Parks and Recreation (Department) approached the Indiana Department of Natural Resources (DNR) for technical and financial lake enhancement assistance. The Department was given a grant under the DNR's "T by 2000" lake enhancement program. The grant funds were used to procure the services of a consulting engineer to perform a lake enhancement feasibility study.

Objectives

The specific objectives of this lake enhancement feasibility study were:

1. To define the conditions within Clear Lake and its watershed that contribute to eutrophication of the lake,

2. To identify technically feasible measures to restore the ecological integrity and recreational value of Clear Lake,

3. To recommend appropriate measures from the identified lake restoration alternatives, based upon engineering feasibility, cost effectiveness, and environmental compatibility.

Scope of the Study

The feasibility study involved five tasks:

1. Data Acquisition and Review. Existing data on Clear Lake ecology were collected and reviewed for use in this study.

2. Field Investigations. Water and sediment quality testing was performed; aquatic vegetation and plankton in the lake were identified.

3. Assessment of Existing Conditions. A map and tally of watershed land use were prepared; residential land management was surveyed; non-point source phosphorus loading to the lake was estimated; a new lake eutrophication index was computed.

4. Study of Alternatives. Identification, description, screening, cost estimating and recommendation of lake enhancement measures.

5. Report and Presentation.

Acknowledgements

We appreciate the assistance given to the study team by the City Parks and Recreation Department. The Park Superintendent, Mr. Dean Heise was particularly helpful, providing assistance during field sampling and circulating the questionnaires to watershed residents. Several agencies provided important data for this study: the County Health Department; DNR's Divisions of Fish and Wildlife, Nature Preserves, and Soil Conservation; the LaPorte County Soil and Water Conservation District; and the City of LaPorte Engineer. The assistance of each of these agencies is appreciated.

PHYSICAL DESCRIPTION OF THE STUDY AREA

Location

Clear Lake is located within the limits of the City of LaPorte in LaPorte County, Indiana. The lake is in Sections 25, 26, and 35 of Center Township. Figure 1 is a location map.

Lake Characteristics

Figure 2 is a map of Clear Lake, showing bottom contours, inlets, and shoreline lands. The entire shoreline is accessible to the public, and there is a boat ramp in the park on the north shore of the lake. The DNR Division of Water published a map of Clear Lake (undated) indicating lake bathymetry and surrounding lands. The map gives the following information:

Legal elevation = 798.20 ft msl
Lake volume = 247 million gallons
(758 acre-feet)
Lake surface area = 106 acres

Field inspections revealed four inlets to the lake, all in the form of stormwater culverts. On the west side, there is an inlet carrying stormwater from the industrial area across Hoedocker Avenue. On the southwest corner of the lake there is a stormwater sewer that drains much of the downtown business district. A dam across the southwest corner of the lake creates a separate pool in front of this stormwater inlet. The dam is breached in the center, leaving a gap about 25 feet wide in it. The original intent of this dam is presently unknown. On the east side of the lake there are two smaller stormwater inlets that drain residential areas to the east. The only other avenues of water entry are overland flow from the immediate surrounding area and direct precipitation.

The lake has no outlets. Water leaves the lake either through evaporation or seepage. Consequently the lake retains all sediment and other conservative (non-degraded) substances that enter the lake. This is a very important aspect of Clear Lake. With the except of small (negligible) sinks (such as fish harvests) all phosphorus that enters the lake stays there and may be available year after year for production of macrophytes and plankton.

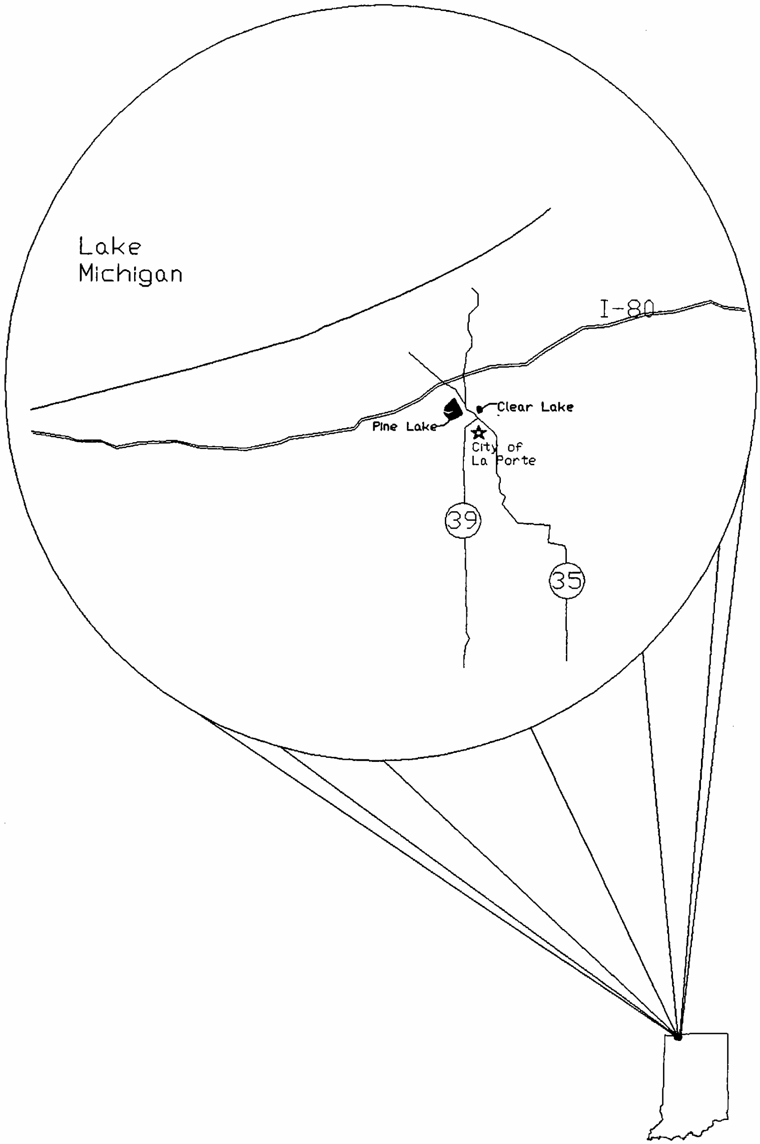


Figure 1
LOCATION MAP

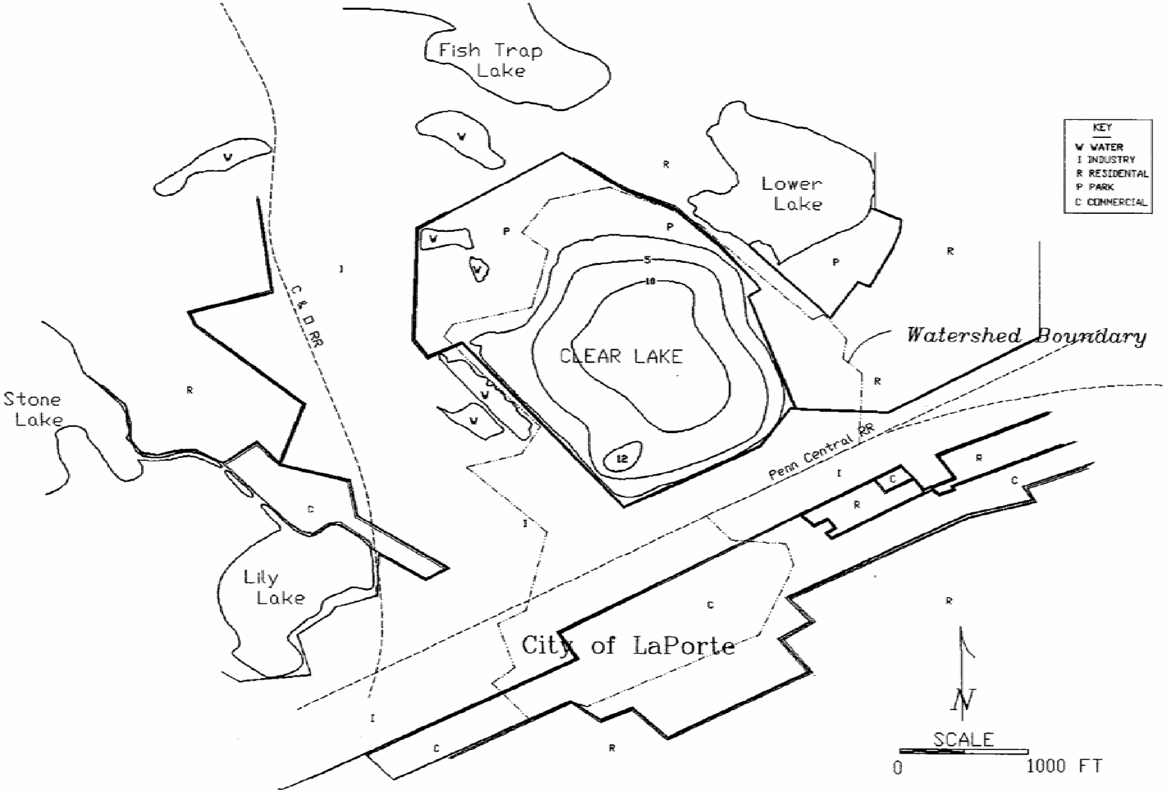


Figure 2
CLEAR LAKE AND
SURROUNDING LAND USES

Hydrogeology

Clear Lake is a kettle lake, formed during the retreat of continental glacial ice sheets in the late Pleistocene period. Clear Lake is largely dependant upon groundwater for maintenance of water levels. The City of LaPorte lies on and near the boundary of two physiographic and hydrologic subdivisions: the Valparaiso Morainal Area to the north and the Kankakee Outwash to the south. These regional features trend generally northeast-southwest across northern Indiana and are underlain by distinct, although hydraulically interconnected, aquifers.

The Valparaiso Morainal Area and the Valparaiso aquifer occur immediately northwest of Clear Lake. This area is characterized by rolling hills and kettle lakes associated with deposition of glacial moraines. The aquifer consists of a heterogeneous layer of sand and gravel intermixed with clay and silt lenses. It is overlain and underlain by glacial tills and, depending upon geology, varies from unconfined (water table) to confined (artesian) conditions. Near LaPorte, the top of the aquifer is 10 to 80 feet below the ground surface and it appears to be 50 to 100 feet thick.

The Kankakee Outwash is a sandy plain of relatively subdued topography which characterizes most of LaPorte County from the Valparaiso Moraines just northwest of Clear Lake to south and east of the City. It is associated with the Kankakee aquifer which immediately underlies Clear Lake as well as the areas to the south and is exposed at the surface over much of its lateral extent. The Kankakee is an unconfined, water table aquifer composed primarily of sand with some gravel and underlain by glacial till. The water table appears to be shallow, generally less than 10 feet below the surface, and would be effected by climatic fluctuations and local pumping. Its saturated thickness ranges from about 100 to 150 feet.

Water well data indicate that the Kankakee aquifer is more productive than the Valparaiso, and may produce up to about 2,000 gallons per minute from a suitably constructed well. The Kankakee is tapped by two municipal wells operated by the City of LaPorte. These are located near Lily Lake about one-half mile southwest of Clear Lake. Based upon data from the city wells, the hydraulic conductivity, k, (permeability) of the Kankakee aquifer was estimated at 0.0054 cm/s using the Forchheimer formula, as follows:

$$k = \frac{0.733\ Q \log(2a/r)}{H^2 - h^2} \qquad \text{Eq. 1}$$

where: Q = well rate = $0.044 m^3/hr$
a = distance from Lily Lake = 50m
r = well radius = 0.2m
H = saturated thickness = 45m and
h = water head in well during pumping = 20m

Recharge to the Valparaiso and Kankakee aquifers is primarily through infiltration of precipitation and other surface waters. The aquifers are hydraulically connected and the Kankakee also appears to be partially recharged by subsurface inflow from the Valparaiso aquifer to the northwest. Recharge to the Kankakee, representing the available groundwater resource potential, was estimated using the above hydraulic conductivity to be about 100,000 gallons per minute per square mile, based on assumed annual precipitation of about 35 inches and net groundwater infiltration of 10 to 12 percent.

The boundary between the Valparaiso Morainal Area and the Kankakee Outwash plain forms a surface water divide approximately at the City of LaPorte. North of the divide, surface water drains northward toward Lake Michigan while south of the divide, it flows towards the Kankakee River. The surface water divide is approximately paralleled by a groundwater divide separating subsurface flow to the north and south. Clear Lake is essentially on the divide and, therefore, is in the recharge area for both aquifers.

Comparing regional groundwater elevations to water levels in Clear Lake suggests that flow is from the lake downward to the Kankakee aquifer by seepage through the lake bed. Therefore, the lake comprises part of the recharge mechanism. The resulting groundwater flow patterns from the lake are apparently in a radial pattern with primary flow to the north, east, and south (Figure 3). Additional flow, at very flat gradients, may occur westward from the lake, but cannot be evaluated with available data. Historic water elevations in Clear Lake during the period 1942 to 1974 averaged two feet higher than other nearby lakes, suggesting that groundwater movement has been from the lake to the aquifer despite variations in climatic conditions.

Although potential sources of contamination exist (landfills, roads, railroad, heavy industry) the likelihood for contamination of Clear Lake from adjacent areas appears to be quite low and mostly related to surface water runoff and/or discharge from stormwater sewers. Potential contamination of the lake from groundwater is unlikely because flow is from the lake to the aquifer, a hydrological condition unlikely to change significantly. Analysis of groundwater samples from monitoring wells west of the lake were reported by the City Water Department to contain little or no contamination.

Watershed Characteristics

Figure 2 is a map of the Clear Lake vicinity, showing the watershed boundary and land use in the watershed. Information used to generate Figure 2 was supplied by the City Engineer's office, and included aerial photographs, topographic maps, sewer maps, and a zoning map.

The watershed area is 278 acres. The use of land in the watershed is primarily for commercial, industrial, residential, or recreational purposes (Table 1). Clear Lake itself is 38% of the catchment area; industrial land is second, at 29%.

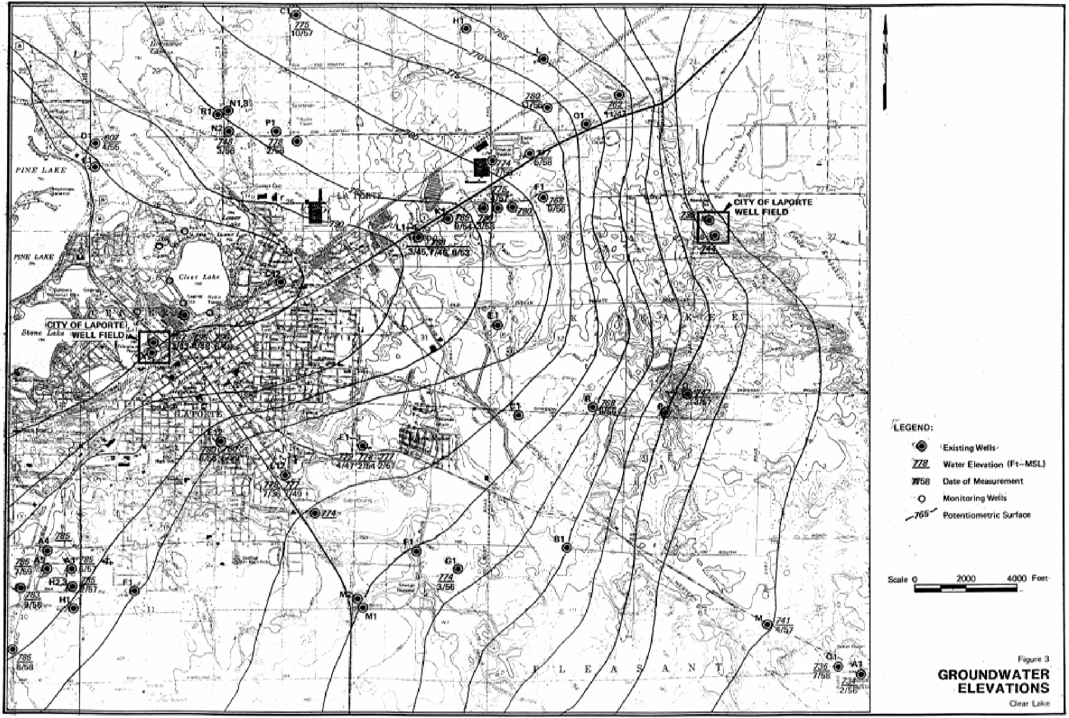


Figure 3

GROUNDWATER ELEVATIONS

Clear Lake

Table 1

CLEAR LAKE WATERSHED LAND USE

Category	Area (acres)
Industrial	80
Residential	19
Commercial	48
Recreational	25
Clear Lake	106
Total	278

Soils in the watershed are primarily classified as urban land-Coupee complex in the county soil survey (SCS 1982). This soil consists of areas of urban land (soil structure cannot be recognized in the traditional manner) and nearly level Coupee soil that is deep and well drained. There are negligible areas of highly erodible land on the northern boundary of the watershed, present as Tracy sandy loam on eroded six to 12% slopes.

AQUATIC RESOURCES

Methods

Water, sediment, and plankton sampling was performed on September 1, 1989. Harza biologists collected a plankton sample using an 80-micrometer mesh Student's plankton net. The plankton were preserved in the field with Lugol's solution. The algal tow was done at the same location sampled for water quality testing, from a depth of two meters (six feet) to the surface, filtering about 65 liters of lake water. Plankton were counted using a Sedgewick-Rafter cell and identified using a key published in APHA et al. (1985).

Water samples were collected on a cloudy, windy day, near the noon hour. Water and sediment samples were taken at, or near, the deepest part of the lake. Lake water samples were collected using a Kemmerer bottle. Initially, we checked for the existence of a thermocline using a Yellow Springs Instruments Model 57 dissolved oxygen meter equipped with a temperature sensor. Upon finding that a thermocline did not exist, the Kemmerer bottle was used to collect a composite sample of equal portions from the top, mid-column, and bottom of the lake.

Water was sampled and tested according to Standard Methods (APHA et al. 1985). Dissolved oxygen (DO) and temperature were measured using the YSI model 57 DO meter; conductivity with a YSI model 33 Salinity-Conductivity-Temperature meter. Total alkalinity was measured on the composite water sample by titration to a calorimetric endpoint. Other parameters were measured in the laboratory from samples collected and preserved in the field according to Standard Methods. Secchi disk visibility was measured in the field using a standard eight-inch black and white disk. Samples were kept on ice from the moment of collection until they reached the laboratory four hours after collection. All meters were calibrated in the field prior to their use according to manufacturer's instructions. The contract laboratory was National Environmental Testing Midwest, of Streamwood, Illinois.

Fisheries

The Department of Natural Resources (DNR) Division of Fisheries last surveyed the fish population of Clear Lake in July of 1980 (DNR 1980). The DNR used gill nets, trap nets, and electrofishing methods to capture fishes in Clear Lake. Thirteen species of fish were collected in the lake. In order of decreasing abundance the DNR found the following fishes in Clear Lake: black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), golden shiner (*Notemigonus crysoleucas*), largemouth bass (*Micropterus salmoides*), lake chubsucker (*Erimyzon sucetta*), and bluegill (*Lepomis macrochirus*). The black crappie sampled were all between six and eight inches, age II+, and exhibited state average growth rates and weights.

The DNR fish management report stated that the dense aquatic weeds in the lake contributed to fish mortality during severe winters, and, they recommended a chemical weed control program for the lake.

Macrophytes and Phytoplankton

The DNR fish management report also listed aquatic plants found in the lake during their survey (Table 2). During Harza's water and sediment sampling visit, essentially 100% of the lake surface was covered by aquatic plants. The only macrophytes seen by Harza biologists were watermilfoil (Myriophyllum spp.) and coontail (Ceratophyllum demersum), and the alga Chara spp.

Table 3 lists the seven phytoplankton species and seven zooplankton species found in the plankton net sample. The sample was nearly all a bluegreen alga Microcystis aeruginosa. Microcystis is a common algal bloom species. It secretes substances that can inhibit growth of other planktonic species of algae. At very high concentrations, Microcystis can be toxic to certain animals that drink the water (Bold and Wynne 1985).

Table 2

AQUATIC MACROPHYTES IN CLEAR LAKE
(Source: DNR 1980)

Common Name	Scientific Name
Submersed Plants	
Watermilfoil	Myriophyllum spp.
Coontail	Ceratophyllum demersum
Emergents	
Water willow	Diathera americana
Cattail	Typha latifolia
White water lily	Nymphaea tuberosa
Arrowhead	Sagittaria latifolia
Algae	
Chara	Chara spp.

Table 3

PLANKTON FOUND IN CLEAR LAKE ON SEPTEMBER 1, 1989

Plankton	Concentration[1/] (units/mL)
EUGLENOPHYTA	
Euglena	0
PYRRHOPHYTA	
Ceratium	1
BACILLARIOPHYTA	
Fragilaria	0
CHLOROPHYTA	
Closterium parvulum	1
CYANOPHYTA	
Microcystis aeruginosa	1,119
Anabaena subcylindrica	12
Lyngbya	64
ZOOPLANKTON	
Copepod nauplii	0
Mesocyclops edax	0
Leptodiaptomus siciloides	0
Eurytemora affinis	0
Skistodiatomus oregonensis	0
Diaphanosoma birgei	0
Keratella quadrata	0
TOTAL	1,198

[1/] A concentration of zero indicates that the species was found in the sample but its concentration was less than one per milliliter.

Water and Sediment Quality

Results of the 1989 water and sediment quality testing are given in Tables 4 and 6. Appendix A includes copies of the analytical reports from the laboratory. The water temperatures at the surface (1 ft.) and at the bottom (10 ft.) were constant, indicating thermal stratification was not present. Both surface and bottom waters had abundant concentrations of oxygen. Based upon the single sampling performed as part of this study, as well as the water quality information contained in the DNR fish management survey (DNR 1980) and knowledge of the lake's depth, Clear Lake does not thermally stratify, or, it stratifies weakly.

In general, Clear Lake water quality is rather alkaline and fertile. For comparison to the data presented in Table 4, the State's water quality standards, which are applicable to Clear Lake, are given in Table 5. Clear Lake, as all lakes and reservoirs in the state, is designated for recreational use (including whole-body contact recreation) and support of warm water aquatic life, and must meet the water quality standards to support these uses. Clear Lake was within the state's standards on the day of sampling.

The US EPA National Eutrophication Survey (USEPA 1974) considered total phosphorus concentrations above 0.02 mg/L to be eutrophic lakes. According to the US EPA, mesotrophic (moderately productive) lakes have 0.01 to 0.02 mg P/L, and oligotrophic lakes (low productivity) have total phosphorus concentrations less than 0.01 mg/L. On September 1, 1989, mean water column total phosphorus in Clear Lake was 0.07 mg/L. Hence, Clear Lake has rather high phosphorus concentrations, and would be classified by the US EPA as eutrophic. The nitrogen to phosphorus ratio (N:P), an indicator of which of these two nutrients limits productivity, was 25. This value places Clear Lake in the phosphorus-limited (Wetzel 1983) category. (It should be noted that the productivity of most freshwaters in North America is phosphorus limited.)

Fecal coliform and streptococcus bacteria are indicators of sewage contamination. The concentrations of these bacteria were low and within the State's standards for public swimming beaches. The fecal coliform to fecal streptococcus ratio (FC:FS) is a general indicator of the source of pollution. FC:FS above 4.1 is considered to be indicative of pollution derived from human excrement, whereas FC:FS less than 0.7 suggests pollution due to non-human sources such as livestock, wildlife or pets (APHA et al. 1985). The FC:FS for Clear Lake was 2.2, likely indicating mixed sources.

Sediment quality data from this study are given in Table 6. Three grab samples were taken from separate locations near the center of the lake and composited for analysis. Sediment nutrient concentrations are moderate for an Indiana lake.

Table 4

WATER QUALITY IN CLEAR LAKE
ON SEPTEMBER 1, 1989

PARAMETER	MEASURED VALUE
Nitrogen, Ammonia	.20 mg/L
Nitrogen, Kjeldahl	.8 mg/L
Nitrogen, Nitrate	<.01 mg/L
Phosphorus, Soluble	.05 mg/L
Phosphorus, Total	.07 mg/L
Coliform, Fecal	28/100mL
Streptococcus	13/100mL
Dissolved Oxygen (surface)	7.0 mg/L
Dissolved Oxygen (bottom)	6.9 mg/L
Temperature	23 °C
Secchi Disk	7.0 ft.
pH	7.95
Alkalinity, Phenolphthalein	0 mg/L
Alkalinity, Total	60 mg $CaCO_3$/L
Conductivity	940 umhos

Table 5

WATER QUALITY STANDARDS APPLICABLE TO CLEAR LAKE

Parameter	Standard
Dissolved Oxygen	Daily Average of 5.0 mg/L Minimum of 4.0 mg/L
pH	6.0 - 9.0
Fecal Coliform Bacteria	Less than 400/100 mL or Less than 200/100 mL per 5 samples in 4-week period

Source: Indiana Administrative Code, Title 330, Article 1. Water Quality Standards.

Table 6

SEDIMENT QUALITY

Parameter	Measured Value
Nitrogen, Ammonia	288.0 ug/g
Phosphorus, Total	480.0 ug/g
Solids, Total	7.50 %
TOC (nonaqueous)	1.43 %
#100 Sieve	13.20 %
Pan (Fines)	0.0 %
#60 Sieve	23.08 %
#230 Sieve	11.72 %
#200 Sieve	29.65 %
#80 Sieve	22.35 %

Other Resources

The DNR Division of Nature Preserves was contacted during this study and requested to review their files for information on the occurrence of threatened or endangered species or their critical habitat, and, the occurrence of natural areas in the Clear Lake vicinity. The Division checked the Natural Heritage Programs database; they found no state-listed species in or around Clear Lake. The Division did however report several species of state endangered, state threatened, and special concern status in the City of LaPorte lakes of Fishtrap, Horseshoe, Lily, Pine, Stone, and Orr.

PROBLEM IDENTIFICATION

Lake Eutrophication Index

A Lake Eutrophication Index (LEI) based upon the Indiana Department of Environmental Management's system (IDEM, 1986) was updated for Clear Lake as part of this study. A LEI is a numerical rating of a lake's trophic or productivity status; the higher the index, the greater the lake's productivity.

Table 7 details our computation of the LEI, based upon the IDEM system. Secchi disk visibility (SD, in feet) was substituted for the LEI variable for light transmittance (L) by the use of equations 2 and 3:

$$L_{1\%} = 2.5 * SD \qquad \text{(Eq. 2)}$$

$$\log L_{3'} = \frac{-2.4}{SD} \qquad \text{(Eq. 3)}$$

where, $L_{1\%}$ is the depth (feet) at which light transmittance is 1% of the incident light, and $L_{3'}$ is the light transmittance at the three-foot depth. The substitution of secchi disk visibility was made per discussions with "T by 2000" lake enhancement staff. Since the LEI is relatively insensitive to the light transmission variable (a possible maximum of 4 out of 75 points), the substitution does not add substantial error to the computation. Also, since there was no thermocline, the plankton data (Table 3) were used twice in the computation of the LEI.

The IDEM computed a LEI in the mid-1970's to be 30 eutrophy points. The updated LEI is 22, a small improvement. Lakes with less than 25 eutrophy points are considered by IDEM to be Class One lakes, that is, the least eutrophic lakes in Indiana.

In spite of the upgrading of Clear Lake to Class I, it is still clearly eutrophic, and is slowly evolving from a lake into a palustrine wetland. Visible symptoms of this aging are the abundance of wetland vegetation, shallowness, and phosphorus concentrations. The LEI reflects only instantaneous conditions and may not accurately qualify the lake's trophic status. Macrophyte abundance and lake depth are not variables in the IDEM LEI, and likely explain the discrepancy between the LEI and an obviously eutrophic lake. In fact, during the summer growing season, during daytime particularly, macrophytes can affect water quality to drive many of the IDEM LEI variables down, by stripping nutrients, increasing dissolved oxygen levels, and increasing water clarity by competing with phytoplankton.

Table 7

ISBH LAKE EUTROPHICATION INDEX FOR CLEAR LAKE

	Parameter	Measured Value (units)	Eutrophy Points
I.	Total Phosphorus	0.07 ppm	3
II.	Dissolved Ortho Phosphorus	0.050 ppm	2
III.	Organic Nitrogen	0.58 ppm	1
IV.	Nitrate Nitrogen	<0.01 ppm	0
V.	Ammonia Nitrogen	0.2 ppm	0
VI.	Dissolved Oxygen Saturation at five feet from surface	83 %	0
VII.	Dissolved Oxygen (% measured water column with >0.1 ppm DO)	100 %	0
VIII.	Light Penetration (Secchi Disk)	8.3 feet	0
IX.	Light Transmission (% transmittance at 3 ft)	51 %	2
X.	Total Plankton (single tow)		
	Vertical tow, 5 ft to surface	1198 cells/mL	2
	Blue-green dominance?	Yes	5
	Vertical tow, from thermocline	1198 cells/mL	2
	Blue-green dominance?	Yes	5
		LEI=	22

Watershed Questionnaire

Harza and the Parks and Recreation Department prepared and circulated a questionnaire to obtain information from watershed residents on land management activities on residential properties. The questionnaire and the detailed results are reprinted as Appendix B. Of the 58 questionnaires circulated, the Park and Recreation Department received 17 responses (29%). Seventy one percent of the respondents were from single family dwellings in the watershed; 12% of the respondents were from multi-family residents, and 12% were commercial or public buildings. One respondent did not asnwer this question. The average lot size of all respondents was 15,570 ft^2 or about one-third acre. 82% stated that the area around their building was mostly covered with mowed lawn.

When queried about the runoff of stormwater from their lots, 53% stated that they thought their land absorbed most of the water, except for major storms. Although questionnaires were only circulated to residents in the drainage area of Clear Lake, most respondents did not believe the runoff from their property entered Clear Lake. Few watershed residents reported using fertilizers or pesticides on their lawns or gardens.

Nonpoint Source Phosphorus Modeling

From this and previous studies, Clear Lake can be classified as eutrophic. Phosphorus is the limiting nutrient. This "T by 2000" feasibility study estimated lake phosphorus (P) loadings and mean annual water column phosphorus concentrations using an empirical (or "black box") model developed by Reckhow (Reckhow and Chapra, 1983; Reckhow and Simpson, 1980). Reckhow's model was selected for use because it quantifies uncertainty and was developed using data from many lakes in the Midwest. Computation of uncertainty is important here because of the limited field data available.

Appendix B includes the details on the non-point source computations. Reckhow's model is based on data from 47 north temperate lakes included in the US EPA's National Eutrophication Survey. The model expresses phosphorus concentration (P, in mg/L) as a function of phosphorus loading (L, in g/m^2-yr), areal water loading (q_s, in m/yr), and apparent phosphorus settling velocity (v_s, in m/yr) in the form of equation 4:

$$P = \frac{L}{v_s + q_s} \qquad \text{(Eq. 4)}$$

By least squares regression of the 47 lakes data, Reckhow fitted apparent phosphorus settling velocity as a weak function of areal water loading:

$$P = \frac{L}{11.6 + 1.2q_s} \qquad \text{(Eq. 5)}$$

Using equation 5 and Reckhow's procedure, phosphorus loadings to a lake and mean annual lake phosphorus concentrations can be estimated. Loadings are estimated based upon land use areas and phosphorus export coefficients. Phosphorus export coefficients for various land use types were carefully selected for use in the model from a compilation and comparison by Reckhow et al. (1980). Non-point sources included in the model were recreational lands, industrial lands, residential areas, commercial lands, and the atmosphere. Export coefficients were selected for these land use types according to climate, location, soil type and texture, human and traffic activities, and vegetative cover. No point sources of phosphorus were found in the watershed or included in the model.

For the sake of practicality, high, most likely, and low export coefficients were selected, allowing computation of high, most likely, and low phosphorus loadings and mean lake water column concentrations. The high and low estimates represent the computation's uncertainty, because actual phosphorus export coefficients were not measured in the Clear Lake watershed. This uncertainty represents error that is in addition to Reckhow's empirical model error and must be included in the computation of total uncertainty. In other words, the range between the high and low estimates reflects the uncertainty inherent in extrapolating Reckhow's compilation of export coefficients to the study area.

Reckhow's phosphorus model predicts a mean annual water column average total phosphorus concentration of 0.03 mg/L. The 55% confidence limits bounding this estimate are 0.016 mg/L and 0.041 mg/L. Given the mean water column total phosphorus concentration of 0.07 mg/L measured in September, 1989, the 0.03 mg/L estimate is not unreasonable, since the model estimates mean annual phosphorus concentrations. The 0.07 measurement is only indicative of a single grab sample, not mean annual phosphorus concentrations.

Reckhow considers this level of phosphorus indicative of eutrophic lakes. Based upon this model, as well as the field water quality data, Clear Lake must be classified as eutrophic, and lacking the chemical and biotic characteristics desired by lake users. Admittedly, there are factors other than total phosphorus important in determining trophic status, but in systems like Clear Lake where phosphorus is the limiting nutrient, total phosphorus is the most important variable in predicting primary productivity in temperate lakes (Prairie et al. 1989).

Table 8 and Figure 4 give the phosphorus model's estimates of most likely phosphorus loadings to the lake. Reckhow's procedure computes nutrient loadings using the unit area loading method, where a nutrient export coefficient for a particular land use is multiplied by the area of that land use in the watershed. Commercial and industrial lands are the two leading sources of phosphorus to the lake, at about 35% and 48% of the total loading, respectively. One phosphorus source that may be significant for this lake is loadings from waterfowl and colonial nesting birds, such as Canada goose, American coot, and mallard. Over 1,000 birds were observed by project staff on Clear Lake one afternoon in October. Canada geese can be a significant source of phosphorus loading to lakes with small watersheds (like Clear Lake), because these birds may feed in a nearby corn field, and, then overnight on the lake and release phosphorus to the water in their feces.

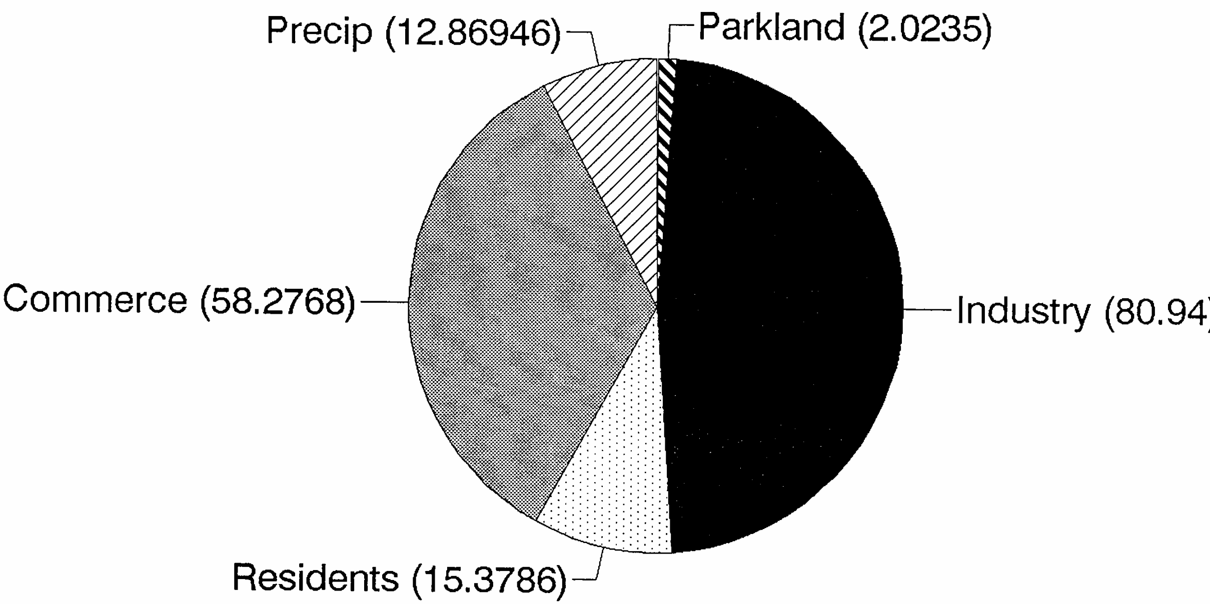
Table 8

NONPOINT SOURCE PHOSPHORUS LOADINGS TO CLEAR LAKE

Source		Loading (kg/yr)
Park land		2
Residential properties		15
Commercial land		58
Industrial areas		81
Atmosphere		13
	Total	169

The estimates of the phosphorus model were used to place Clear Lake on Vollenweider's phosphorus loading plot, Figure 5 (Vollenweider 1975). For comparison, three other lakes in northern Indiana, including one other in LaPorte County, are also included in Figure 5. The plot has three basic zones, and a lake's datum will fall within one of those zones: eutrophic, mesotrophic, or oligotrophic. The upper zone is eutrophic lakes; the bottom zone is oligotrophic lakes. Mesotrophy is indicated by a datum falling in the midregion of the plot.

Figure 4
PHOSPHORUS LOADINGS TO CLEAR LAKE



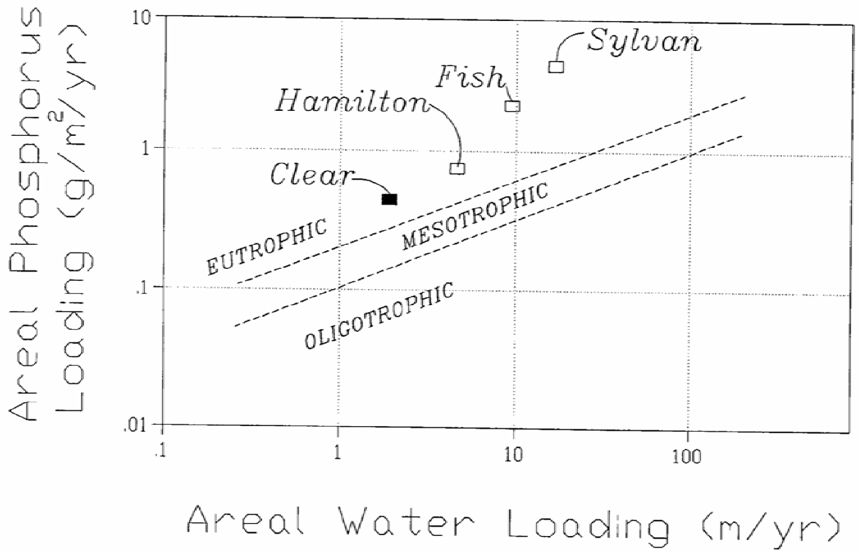


Figure 5
VOLLENWEIDER'S LOADING PLOT

Conclusion

In spite of the reduction of Clear Lake's LEI from 30 to 22 points, and reclassification as a Class I lake, Clear Lake is unequivocally eutrophic. It is quite shallow and is completely covered each summer with aquatic vegetation. Although the total and soluble phosphorus concentrations are moderate for a Hoosier lake, the macrophytes undoubtedly have tied up large amounts of phosphorus, taken up from both sediment and water. The relatively low phytoplankton concentration, good water clarity, and high daytime dissolved oxygen concentrations are consistent with this phenomenon.

EVALUATION OF LAKE ENHANCEMENT ALTERNATIVES

Clear Lake is a valuable resource for the City of LaPorte. The uses of the lake are being impacted by the accelerated aging (or cultural eutrophication) of the lake. The obvious symptoms of this accelerated aging are the large beds of aquatic macrophytes, the summertime algae blooms, and the sediment deltas at the mouth of inlets. Less obvious symptoms include gradual decreases in lake depth and water clarity. Below, we describe various methods for remedying these lake problems.

Approach

The purpose of an engineering feasibility study is to identify, compare, and screen project alternatives and to select one or more alternatives for further study, typical a design level study. Alternatives for enhancing Clear Lake were evaluated using a three-level procedure, with the depth of study increasing as the list of alternatives narrowed to those most feasible. The evaluation system's three levels are:

Level 1. **Initial Identification** - A comprehensive list of reasonable lake enhancement methods was compiled.

Level 2. **General Screening** - Alternatives which were obviously not applicable to Clear Lake, had unacceptable environmental impacts, or unproven technology were eliminated from further consideration.

Level 3. **Feasibility Evaluation** - Alternative methods were evaluated for technical feasibility for enhancing Clear Lake. Those alternatives remaining for evaluation at this level of study were prioritized for implementation based on effectiveness and cost.

Level One - Identification

A list of macrophyte control alternatives is presented in Table 9. Table 10 is a list of alternatives for reducing phosphorus or sediment loadings to Clear Lake. Beside each listed alternative are comments reflecting the applicability to the specific problem at Clear Lake.

Table 10 does not include many Best Management Practices (BMPs) for urban watersheds. BMPs for urban runoff control are listed in Table 11 and include source control practices (like increasing infiltration of storm water, retention of runoff, reduction of erosion, air pollution control, and street sweeping) and reduction of pollutant delivery to surface waters (changes in storm drainage systems, infiltration and sedimentation basins, flow equalization basins, and treatment of runoff). References on urban BMPs include Novotny and Chesters (1981), HHRCDC (1985), US EPA (1980) and SCS (1969). BMPs are very important for maintaining water quality, and, in LaPorte would have benefits not only to Clear Lake, but to the various other lakes in the city. There are also policies than local governments can implement to improve and protect water quality in urban watersheds. Examples of such policies include HERPICC (1989) and ordinances protecting wetlands.

Table 9

ALTERNATIVES FOR CONTROLLING AQUATIC MACROPHYTES IN CLEAR LAKE

Method	Description	Suitability
Water Level Fluctuations	Exposes sediments to prolonged freezing and drying, killing roots and some species' seed. Submerges & kills some species.	Lake has no surface outlet or other mechanism for significantly lowering water level; can have adverse effects on fisheries and wildlife.
Lake Shading	Dyes and water surface covers can shade and kill many plants.	Not suitable for large lake areas. Water surface covers, like black plastic, may be suitable for small, localized areas. Does not remove organic matter or nutrients from lake.
Phytophagous Fishes	Grass carp and other exotic plant-eating fishes can control some macrophytes.	Not legal in Indiana; can have adverse environmental impacts. Consider in the future if legalized.
Insects	Insects consume plants.	Technology poorly developed for northern climes.
Plant Pathogens	Microorganisms introduced to lake cause diseases in macrophytes.	Technology undeveloped.
Harvesting	Cutting and removing plants by mechanical means.	Requires repeated treatments; technology well developed; Clear

Table 9 (cont'd)

		Lake has excellent access for off-loading weeds.
Herbicides	Use of selected chemicals to control plants.	Short-term effectiveness; technology well established. Does not remove organic matter or nutrients from lake.

Table 10

ALTERNATIVES FOR REDUCING SEDIMENT AND PHOSPHORUS LOADINGS TO CLEAR LAKE

Method	Description	Suitability
Hypolimnetic Withdrawal	Nutrient-rich hypolimnetic water discharged from the lake during stratification, resulting in a net annual loss of P from the system.	Lake does not thermally stratify; also, no mechanism currently exists at outlet for deep water withdrawal.
Nutrient Diversion	Diverting incoming P-rich waters to another basin or downstream of lake.	Inlets could be diverted to other lakes; will require reconstruction of storm sewer system in downtown area.
Dilution or Flushing of Nutrients	Diluting lake with large volumes of nutrient-poor water.	No suitable water supply.
Lake Phosphorus Inactivation	Chemical binding of sediment phosphorus by Al salts.	Well tested; especially effective in lakes with high internal phosphorus loadings and low external loadings.
Sediment Oxidation	Adding a reducing agent, like nitrate, to organic-rich sediment prevents hypolimnetic anoxia and sediment P release.	Effective, but not well tested, and must be repeated annually or biannually.

Table 10 (cont'd)

Sediment Removal	Dredging removes the source of internally loaded P and increases depth, reducing the likelihood of recurring weed problems.	Suitable, frequently recommended, but costs are high.
Hypolimnetic Aeration	Oxygenation of hypolimnion prevents sediment release of phosphorus.	Unsuitable since Clear Lake does not thermally stratify.
Sediment Trap	Functions as trap for particle-bound phosphorus, and as a biological treatment basin.	Effectiveness is design-dependant. Maintenance will be required.
Artificial Circulation	Eliminates thermal stratification and aerates lake, using air bubbles or mechanical mixers.	Generally used to restore eutrophic lakes having plankton or metal (Fe, Mn) problems rather than for macrophyte control.

Table 11

NONPOINT POLLUTANT SOURCES AND CONTROL MEASURES FOR URBAN WATERSHEDS

Source	Control Measures
Street Surfaces	Street Cleaning Street Repair Alternative De-icing Methods Litter Control Pet Litter Control Cleaning Catch Basins Store and Treat Runoff
Parking Lots	Street Cleaning Leaf Removal Alternative De-icing Methods Use of Porous Pavement Store and Treat Runoff
Vacant Land	Control Grass Types Control Fertilizers & Pesticides Control Litter Regrade and Seed Disturbed Areas
Rooftops	Discharge Gutters to Lawns
Construction Sites	Clean Catch Basins Clean Storm Sewers and Drainage Channels Retain Runoff Regrade Disturbed Areas Direct Runoff Away form Contaminated Sites
Landscaped Areas	Leaf Removal Control Grass Types Control Fertilizer, Pesticides Control Dog Litter Store and Treat Runoff
Other (Industrial and Solids Waste Runoff)	Control Use of Vacant Land Control Direct Discharge to Storm Drains Eliminate Cross-Connections with Sanitary Sewers Direct Runoff Away from Contaminated Areas Store and Treat Runoff

Level Two - Screening

The initial list of alternatives was screened, and only those determined to be suitable for implementation were carried forward to the feasibility evaluation stage. The criteria for this screening included obvious applicability and utility, unacceptable environmental or social impacts, legal constraints, and unproven technology.

The macrophyte control alternatives carried on to the feasibility level of study were mechanical harvesting, herbicides, and shading using dyes. Harvesting is the only method among these three that removes organic matter and nutrients from the lake. Water level fluctuations can control some types of macrophytes quite well. However Clear Lake's only outlets are groundwater seeps and atmospheric losses. Lowering the water level of Clear Lake would require pumping to other lakes, and, although this is technically feasible, direct adverse impacts would occur on the fish population and indirect adverse effects would occur to the waterfowl using Clear Lake for foraging.

Three biological weed control mechanisms were identified; only one of these is developed sufficiently for temperate climates: weed-eating fishes. Insects and microorganisms are under study, but currently are not appropriate this far north. Triploid (genetically sterile) grass carp (Ctenopharyngodon idella) should be considered should this alternative ever be permitted in Indiana. However, they are illegal at present. Other alternatives not carried forward for feasibility evaluation, and the reasons for their elimination, are given in Table 9.

Phosphorus control alternatives evaluated included both in-lake and watershed source control of phosphorus. In-lake phosphorus control basically involves restriction of sediment-generated or recycled phosphorus. In-lake phosphorus (also referred to as internal phosphorus) sources are generally significant in lakes that have accumulated large amounts of this nutrient in their sediments and are able, through summer anoxia, to recycle the phosphorus. Although Clear Lake obviously has accumulated phosphorus (there is no outlet), summer anoxia are weak in this shallow lake and when they do occur are not likely for periods long enough to allow large amounts of phosphorus to enter the water column. Hence control of in-lake phosphorus will not significantly affect the lake trophic status, and only watershed control methods are carried forward to the feasibility level of study.

Watershed control of phosphorus inputs to the lake is generally linked with control of nonpoint soil erosion and sedimentation through BMPs. Phosphorus is generally transported in streams adsorbed to soil particles, so removal of the soil particles from the stream system frequently removes incoming phosphorus as well. Watershed control of phosphorus and sediment loadings carried to the next level of study includes use of sediment traps at the mouths of stormwater drains.

Level Three - Feasibility Evaluation

Harvesting. Harvesting, or cutting and removing aquatic plants, has been practiced in Midwestern lakes for many years. Although harvesting is especially effective at immediately improving lake uses, it has some lake restorative value because the plants are removed from the lake. Because they are removed, the plants do not decompose in the water, consume dissolved oxygen, and release their nutrients to the water column. Disposal of the weeds is not usually a problem. The vegetation makes excellent mulch and fertilizer for parks and gardens. Harvesters should cut the vegetation at least five feet deep. Harvesting, although easiest in water five to six feet deep, can be done in water that is deep enough to float the harvester (18 to 24 inches).

Macrophyte mowers are available but they do not remove the vegetation from the lake, and, although considerably less expensive than harvesters, mowers are not recommended.

Weed harvesters are available from specialty manufacturers. Alternatively, contract harvesting can be periodically performed. Experience indicates that during the first year of harvesting, spring, mid-summer, and late summer harvesting should be done. After this first year program, weed growth is generally less and a single harvesting is generally sufficient. However, watermilfoil, one of the most common macrophytes in Clear Lake builds up rather heavy biomass levels quickly and harvesting can be greatly slowed, so more than one harvesting each year is generally done to keep the biomass levels down. Assuming Clear Lake requires three harvestings the first year, and two each season thereafter, first year harvesting costs will be approximately $45,000, and costs in succeeding years will be about $34,000.

Because there are several lakes in LaPorte, and there are macrophyte problems on some of these lakes, the City can likely implement a long-term harvesting program for substantially less than contracting for the harvesting. Table 12 itemizes the costs for a harvesting program on Clear Lake.

Table 12

MACROPHYTE HARVESTING PROGRAM

Purchase

Item	Amount
Aquamarine H5-200 Harvester	$38,700
Trailer/Conveyer	14,400
Delivery	300
	$53,400

Operation

Item	Amount
Labor (175 ac, 3.4 ac/hr @ $10/hr)	$6,000
Fuel (2 gal/hr @ $1/gal)	1,200
Maintenance (10%)	5,340
	$12,540

Adverse ecological effects are few. The weeds will return and harvesting will need to be repeated. Harvesting is generally increasingly effective in later years. With fewer macrophytes, phytoplankton concentrations may increase, and water clarity may decrease. Macrophytes should not be harvested from certain locations, such as the mouths of inlets.

Access to the lake front for offloading harvested weeds is excellent at Clear Lake. The shoreline is paralleled by roads, and is unencumbered by private docks or piers. Disposal of the weeds should not be a problem either; the Park and Recreation Department can compost the weeds for later use as a soil amendment.

Herbicides and Shading. The City has never applied herbicides or dyes to Clear Lake. Controlling macrophytes using herbicides is effective, but herbicide use is not lake restoration (i. e., does not remove nutrients). Some herbicides are specific to certain plants. Application needs to be done according to the manufacturer's instructions, and in Indiana, by licensed applicators. Likewise, dyes that decrease light penetration into the water also control plants, but cannot be considered a lake restoration method. Neither of these techniques addresses the causes of weed growth, nor do they remove weed organic matter or nutrients from the lake. These methods cause the plants to die, to decompose on the lake bottom, and eventually to release their nutrients back to the water column. Therefore, due to the lack of long-term effectiveness, the use of herbicides or dyes are not recommended for implementation, or, for further evaluation.

Sediment Traps. Underwater dams at the mouths of stormwater drains can be effective at reducing sediment loadings to urban lakes (Hey and Schaefer 1983). The traps must be periodically dredged to maintain their effectiveness. The 1957 DNR map of Clear Lake shows a dam, extending above the water surface, at the southwest corner of the lake where the sewer draining downtown enters the lake. Remnants of this dam are still there, but it has been breached in the center. There are visible accumulations of sediment behind the dam.

As scaled from the DNR map, the dam is about 750 feet long. It is about 150 feet from the stormwater drain. The surface area impounded by this dam is about one and one-half acres.

The effectiveness of the existing sediment trap can be improved by regularly cleaning it of accumulated sediment, and by closing the breach using a pervious rock barrier. This would retard low flows to achieve greater settling time, and would reduce the flushing out of settled material during high flows. The size of the existing facility allows only retention of fine grained sediment that enters during precipitation of less than 0.2 inches per hour, estimated using the rational equation and particle settling velocities of 0.01 cm/s (Chow 1964). Precipitation events exceeding this will wash most fine sediment into Clear Lake.

Restoration of the existing sediment trap would require repairing the dam and removing the accumulated sediment. A dragline would be used to excavate the accumulated sediment to an average depth of about four feet, about 10,000 yd^3. For removal of 10,000 cubic yards, equipment costs are estimated at $34,000 with labor costs of $63,000. The underwater dam could be restored by replacing the breach with riprap, estimated to cost $3,000.

However, because the settling velocity of fine sediments is generally much less than the existing trap's surface loading rate for precipitation events greater than 0.2 inches per hour, it is recommended that the design phase include re-design of this sediment trap for larger storm events. At a minimum, the design phase should include tasks to specifically assess:

1. Analysis of storm drain inflow and selection of a design storm event;
2. Collection of storm water inflow and subjection of sample to column settling tests;
3. Collection of previously deposited sediment and testing for particle size distribution and chemical content;
4. Computation of average annual sediment load;
5. Update the lake's requirement for additional sediment traps, in light of the ultimate commercial redevelopment of the former Allis Chambers plant;
6. Location of a site for disposing of the sediments removed from the trap and for continuing maintenance;

Participate in acquiring needed permits

7. Preliminary scoping of permitting requirements for construction of a new sediment trap; and,

8. Development of a maintenance schedule.

Recommendations for Implementation.

The following recommendations are made based upon the feasibility evaluations conducted during this study.

Macrophyte Control. Based upon the above studies of aquatic weed control, harvesting is recommended for future management of the lake's weed problem. The City of LaPorte may be cost effectively served by purchasing and operating its own weed harvester. Herbicides are not recommended for Clear Lake.

Nonpoint Source Pollution Control. Best management practices for the city should be written into local ordinances. BMPs will provide protection of not only Clear Lake, but Pine Lake and the other lakes in the city. The "T by 2000" Program includes technical assistance for non-agricultural erosion control. Services under this program include providing detailed soil mapping and interpretations on lands being considered for intense or specialized use, making on-site evaluations to identify and characterize potential erosion problems, to assist in solving these problems, and presenting programs to interested groups on urban watershed management.

The Park and Recreation Department should apply to the "T by 2000" program for design and implementation assistance for reconstruction of the sediment trap on the main inlet to Clear Lake. During the design phase, specific studies have been recommended for study to optimize the function of the sediment trap.

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ANALYTICAL REPORT

Mr. David Pott
HARZA ENGINEERING CO.
150 So. Wacker Drive
Chicago IL 60606

09-13-89

Sample No.: 89425

Sample Description: Clear Lake; Water

Date Taken: 09-01-89 1200

Date Received: 09-01-89 1600

Nitrogen, Ammonia	0.20	mg/L
Nitrogen, Kjeldahl	0.58	mg/L
Nitrogen, Nitrate	<0.01	mg/L
Phosphorus, Soluble	0.05	mg/L
Phosphorus, Total	0.07	mg/L
Coliform, Fecal	28.	/100 mL
Streptococcus	13.	/100 mL

W. Mottashed
William H. Mottashed
Division Manager

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ANALYTICAL REPORT

Mr. David Pott
HARZA ENGINEERING CO.
150 So. Wacker Drive
Chicago IL 60606

10-11-89

Sample No.: 89427

Sample Description: Clear Lake; Sediment

Date Taken: 09-01-89 1200

Date Received: 09-01-89 1600

Nitrogen, Ammonia	288.	ug/g
Phosphorus, Total	480.	ug/g
Solids, Total	7.50	%
TOC (Nonaqueous)	1.43	%
#100 Sieve	13.20	%
Pan (Fines)	0.00	%
#60 Sieve	23.08	%
#230 Sieve	11.72	%
#200 Sieve	29.65	%
#80 Sieve	22.35	%

Results on a dry weight basis.

W. Mottashed
William H. Mottashed
Division Manager

Sent our 58 questionnaires
Received 17 responses

CLEAR LAKE ENHANCEMENT PROJECT
LANDOWNER QUESTIONNAIRE

The City of LaPorte Park and Recreation Department is undertaking a study of Clear Lake to determine the causes of lake eutrophication and weed growth and potential solutions to these problems. Since rainwater runoff can affect the lake, the Department is surveying watershed landowners about their land, and lawn tending practices through this questionnaire.

1.) What type of dwelling is this building?

A. Single family home 12

B. Multi-family apartment house 2

C. Commercial or public building 2

D. No response 1

2.) What is the approximate size of your lot? see on back of complete questionnaire

3.) The area around your building is . . .

A. Mostly pavement 1

B. Mostly covered with mowed lawn 14

C. Mostly covered with unmowed lawn & brush 0

D. Mostly a garden 2

E. No response 1

4.) What percentage of your lot is paved or covered by a building?

A. 0% - 25% 7

B. 25% - 50% 6

C. 50% - 75% 3

D. more than 75% 0

E. No response 1

(OVER)

5.) **Where does the rainwater from your roof, driveway and sidewalk go?**

A. Directly to the storm sewer (gutter down spouts directly connected to storm sewer) 4

B. Flows into yard and excess runs into storm sewer 6

C. Stored for use during dry weather 1

D. Land can absorb the stormwater and that from the road and other paved areas, except for major storms 9

E. No Response 1

6.) **Does the stormwater from your property flow to Clear Lake?**

A. Yes 2

B. No 9

C. Unknown 4

D. No Response 2

7.) **Do you use a professional lawn care service to treat your lawn? If so, who?**

No 15; no response 2

8.) **How frequently do you apply fertilizers to your lawn or garden?**

A. Never 10

B. Once each year (time of year is ____________) 7 (spring-4; Mar/Apr-1)

C. Two or three times per year 0

D. Four or more times each year 0

E. Professional lawn care service fertilizers according to their own schedule 0

9.) **Your lawn/garden fertilization schedule is influenced by which of the following?**

A. Soil testing 0

B. Fertilizer applied just before a rain 4

C. Fertilizer applied following a rain 2

D. Other (please describe) ____________ 1-manure every other fal

E. None 3

F. No Response 7

10.) What brands of fertilizers do you use?

Scotts/Turf Builder Plus Halts-1
6/8/10-1
Any-1
Rapid Gro-1
Natural-1

None-7
No Response-5

11.) How often do you apply pesticides or herbicides?

A. Never or not applicable	9	(tomato dust-1)
B. Frequently	0	
D. Occasionally	0	
E. No Response	3	

12.) Where do you put the extra pesticide and/or container washings?

A. Storm sewer	0
B. Sanitary sewer	0
C. There is no extra pesticide and the containers are not washed.	6
D. No Response	8
E. Don't use any	2

13.) What brands of pesticides or herbicides do you use?

Ferti-lome/Diazinon-1
Seven Garden Dust-1
Rotonone-1
None-7
No Response-6

14.) Any additional comments?

*I believe some of the lottery money should come back to LaPorte to help clean up and maintain the parks here.

*What happened to the money that was raised in the fund raising projects?

*We rent.

*Thanks to the Park Dept. and area businesses for their efforts to remedy the unsightly weed growth in one of LaPorte's fine and valuable lakes.

*Let's make sure there is plenty of grazing food for our wild ducks and geese and other wildlife.

*All the rain water comes off Park Street and drains down the street sewer. I do believe Allis Chalmers drains all their water into Clear Lake. It is about time they are going to clean up this lake.

*During Koomler reign, wanted to donate this land which adjoins Old City Park to city to make it into a playground. After some study said no because of excessive rain my land would suffer. Never sprayed for mosquito for mos population.

Responses to question #2

32x104
38x100
45x198
49x100
49x198
50x60
50x100
50x110
100x200
105x108
110x250
200x150
200x300
250x100
no response-2

LAKE PHOSPHORUS MODEL
(Based upon Reckhow and Simpson, 1980)

P = L/(11.6 + 1.2 * qs)
Where: P = Lake phosphorus concentration (mg/L)
L = Phosphorus loading (g/sq m-yr)
qs = Areal water loading (m/yr)

Estimation of qs for Clear Lake:
Q = (Ad * r) + (Ao * Pr)
and
qs = Q/Ao
Where: Q = Inflow water volume (cu m/yr)

Ao = Lake surface area =	428,982 sq m		
Ad = Watershed area =	1,125,066 sq m		
r = Total annual unit runoff =		0.296	m/yr
Pr = Mean annual net precipitation =		0.901	m/yr

Q = 7.20E+05 cu m/yr
qs = 1.68 m/yr

Estimation of L for Clear Lake
M = (Ep * Ap) + (Er * Ar) + (Ec * Ac) + (Ei * Ai) + (Ep * Ao) + PSI
and
L = M / Ao
Where: M = Total phosphorus mass loading (kg/yr)
Ep = P export coefficient for parkland (kg/ha-yr)
Ap = Area of parkland (ha)
Er = P export coefficient for residential land (kg/ha-yr)
Ar = Area of residential land (ha)
Ec = P export coefficient for commercial land (kg/ha-yr)
Ac = Area of commercial land (ha)
Ei = P export coefficient for industrial land (kg/ha-yr)
Ai = Area of industrial land (ha)
Ep = P export coefficient for precipitation (kg/ha-yr)
PSI = Point source inputs

Clear Lake Phosphorus Model

Sources	Area		Phosphorus Export Coefficients High	Most Likely	Low	
Parkland	10.1	ha	0.3	0.2	0.1	kg/ha-yr
Residents	7.7		3.0	2.0	0.5	
Commerc	19.4		4.0	3.0	1.5	
Industry	32.4		4.0	2.5	0.4	
Precip	42.9		0.4	0.3	0.1	
	113	ha				

	Phosphorus Mass Loading High	Most Likely	Low	
Parkland	3	2	1	kg/yr
Industry	130	81	13	
Residents	23	15	4	
Commerc	78	58	29	
Precip	17	13	4	
M =	250	169	51	kg/yr

Areal Phosphorus Loading (L):

High = 0.6 g/sq m/yr

Most likely = 0.4

Low = 0.12

Lake Phosphorus Concentration (P):

High = 0.043 mg/L

Most likely = 0.029

Low = 0.009

November 10, 1989

ESTIMATION OF UNCERTAINTY (St)

log P (most likely) =	-1.537	
"Positive" model error =	0.0099	mg/L
"Negative" model error =	-0.0074	mg/L
"Positive" loading error =	0.0069	mg/L
"Negative" loading error =	0.0101	mg/L
"Positive" uncertainty =	0.0121	mg/L
"Negative" uncertainty =	0.0125	mg/L

55% confidence limits (lower) =	0.016	mg/L
55% confidence limits (upper) =	0.041	mg/L
90% confidence limits (lower) =	0.0039	mg/L
90% confidence limits (upper) =	0.053	mg/L

GLOSSARY OF TECHNICAL TERMS

Anoxia	A condition of no oxygen in the water. Often occurs near the bottom of fertile stratified lakes in the summer and under ice in late winter.
Alkalinity	The buffering capacity of water.
Coliform bacteria	A group of microorganisms that is the principal indicator of the suitability of water for domestic or other uses and the sanitary quality of that water.
Epilimnion	Uppermost, warmest, layer of a lake during summertime thermal stratification. The epilimnion extends from the surface to the thermocline.
Eutrophic	Waters with a good supply of nutrients and hence high organic production.
Eutrophication	The process of lake aging, involving physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment of a lake. If the process is accelerated by man-made influences, it is termed cultural eutrophication.
Hypolimnion	Lower, cooler layer of a lake during summertime thermal stratification.
Kjeldahl nitrogen	Organic nitrogen plus ammonia nitrogen.
Macrophytes	Rooted and floating aquatic plants, commonly referred to as waterweeds.
Mesotrophic	Waters moderately rich in plant nutrients.
Non-point source pollution	Pollutants that do not originate from a pipe or single source.
Oligotrophic	Waters with a small supply of nutrients and hence low organic productivity.
Orthophosphorus	A simple form of phosphorus that is readily available for uptake by plants.
Pheophytin	A product formed by the breakdown of chlorophyll, the primary plant pigment responsible for photosynthesis.

Phytoplankton	Microscopic algae that float freely in open waters.
Fecal streptococci	A group of organisms indicative of fecal pollution from warm blooded animals.
Thermocline	A horizontal plane across a lake at the depth of the most rapid vertical change in temperature and density in a stratified lake; the transition zone between the epilimnion and the hypolimnion.
Wetland	Areas that are inundated or saturated by surface or ground water, with vegetation adapted to living in saturated soil conditions. Generally includes swamps, marshes, bogs, and similar areas.